

(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11)

EP 0 997 562 A2

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
03.05.2000 Bulletin 2000/18

(51) Int. Cl.<sup>7</sup>: D03D 9/00, D03D 19/00,  
D03J 1/06

(21) Application number: 99307017.6

(22) Date of filing: 03.09.1999

(84) Designated Contracting States:  
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE  
Designated Extension States:  
AL LT LV MK RO SI

(30) Priority: 04.09.1998 GB 9819288

(71) Applicant: DON & LOW LIMITED  
Forfar, Angus DD8 1FR, Scotland (GB)

(72) Inventor: Hoy, Gregor  
Glenagilvie, Glamis DD8 1UP (GB)

(74) Representative:  
Moreland, David, Dr. et al  
Cruikshank & Fairweather,  
19 Royal Exchange Square  
Glasgow G1 3AE (GB)

### (54) Bonded woven fabric product and method for its manufacture

(57) There is disclosed a bonded woven fabric product and a method for its manufacture. The product finds use as a tufting substrate for carpet manufacture. Existing problems in the field include deformation of fabric weave in fabric stretched in the fabric plane; deflection of flat rectangular polypropylene tapes giving stitch placement defects within a carpet; and reduced dimensional stability, strength and tuft lock in mechanically fibrillated tapes. The invention provides a woven prod-

uct (Fig. 1, 5a) comprising a plurality of first threads (10a), and a plurality of second threads (15a), wherein contact portions (20a) provided along each first thread (10a) contact respective contact portions (25a) provided along each second thread (15a), wherein further each first thread (10a) is bonded to each second thread (15a) at the respective contact portions (20a, 25a).

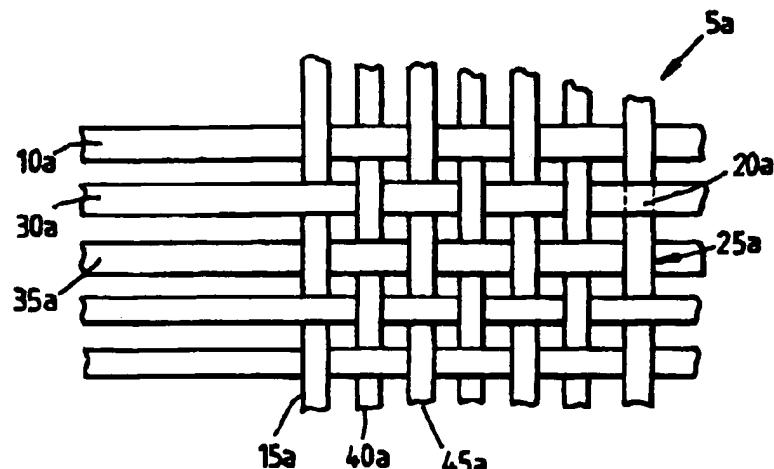


Fig. 1

**Description****BACKGROUND OF THE INVENTION**

[0001] The present invention relates to an improved woven product, and to a method of manufacturing same.

[0002] Woven fabrics made from plastics material for use, for example, as a woven primary tufting substrate in the manufacture of carpets are known. Such known fabrics suffer from a number of problems. For example, deformation of the substantially uniform fabric weave can occur if the fabric is stretched in the plane of the fabric. Further fabrics produced by weaving of flat rectangular cross section polypropylene tapes offer little resistance to penetration by a tufting needle. However, it has been found that at the point of entry the needle may cause tapes (e.g. warp tapes) to deflect.

[0003] Such deflection of the tape adversely affects regularity of stitch placement thereby leading to defects within a finished carpet.

[0004] Mechanical fibrillation of tapes has been employed to seek to reduce the tendency of tapes to deflect during tufting. However, this has been found to lead to reduced dimensional stability, loss of strength, and a drop in tuft lock.

[0005] It is an object of at least one aspect of the present invention to obviate or mitigate at least one of the aforementioned problems in the prior art.

**SUMMARY OF THE INVENTION**

[0006] According to a first aspect of the present invention there is provided a woven product comprising a plurality of first threads, and a plurality of second threads, wherein contact portions provided along each first thread contact respective contact portions provided along each second thread, wherein further each first thread is bonded to each second thread at the respective contact portions.

[0007] Advantageously each contact portion of each first thread is bonded (fused) to each respective contact portion of each second thread by means of a thermal and/or pressure bonding process.

[0008] Advantageously adjacent contact portions of each first thread are provided alternately on first and second opposing outer surfaces of each first thread.

[0009] Advantageously adjacent contact portions of each second thread are provided alternately on first and second opposing outer surfaces of each second thread.

[0010] Advantageously the first and second opposing outer surfaces of each first thread are formed from a first material having a melting point and/or softening point lower than that of a second material from which the first and second outer surfaces of each second thread are formed.

[0011] Alternatively the first outer surface of each first thread is formed from a first material having a lower

melting point and/or softening point than that of a second material from which the second outer surface of each second thread is formed, and further the first outer surface of each second thread is formed from a third material having a lower melting point and/or softening point than that of a fourth material from which the second outer surface of each first thread is formed.

[0012] The third material and the first material may be one and the same.

[0013] The fourth material and the second material may be one and the same.

[0014] The melting point of the first/third material may be between 20 and 50°C less than that of the second/fourth material, and preferably approximately 25°C less.

[0015] Advantageously the melting point of the first/third material may be approximately 120°C.

[0016] Advantageously the melting point of the second/fourth material may be approximately 160°C.

[0017] The first threads may comprise warp threads or weft threads.

[0018] The woven product may be in the form of a plain weave.

[0019] Alternatively the woven product may be in the form of a leno weave including interweaved pairs of first threads.

[0020] Advantageously each first thread comprises a core layer made of one material, and first and second opposing outer layers made of at least one other material, the/each other material having a melting point/softening point lower than that of the one material.

[0021] In this case each second thread may be made from a further material, the further material having a higher melting point/softening point than the at least one other material(s).

[0022] In this case the further material, and the one material may be one and the same.

[0023] Alternatively, each second thread may comprise a further core layer made from a further material, and further first and second opposing layers made of at least one further other material, the further material having a higher melting point/softening point than the at least one further other material.

[0024] In this case the one material, and the further material may be one and the same, and further the at least one other material and the at least one further material may be one and the same.

[0025] The one material/further material may comprise polypropylene, e.g. a polypropylene homo-polymer, block co-polymer or ter-polymer. The further material may comprise polypropylene, e.g. a polypropylene homo-polymer, block co-polymer or ter-polymer.

[0026] The at least one other material/one further other material may comprise ethylenepropylene, e.g. an ethylenepropylene random co-polymer, ethylenepropylene block co-polymer or ter-polymer.

[0027] The first and/or second threads may advantageously comprise flat rectangular cross-section tapes.

- [0028] In such case the first layer/further first layer may comprise between 1% and 50% of the thickness of the tape.
- [0029] Further, in such case the second layer/further second layer may comprise between 1% and 50% of the thickness of the tape.
- [0030] Each tape may have an approximate thickness in the range 30µm (Micron) to 300 µm (Micron).
- [0031] Further each tape may have an approximate width in the range 0.5mm to 5mm.
- [0032] Advantageously where the first thread comprises a warp thread, the tape may have a width of approximately 1mm.
- [0033] Advantageously also where the second thread comprises a weft thread, the tape may have a width of approximately 2.5mm.
- [0034] Each tape may have a breaking load of approximately 400 to 450 mN/TEX.
- [0035] Advantageously, first threads substantially equally spaced one from the other have a higher modulus than the remaining first threads. For example, where the first thread comprises a warp thread, every 50th to 60th warp thread (or alternatively the thread positioned at approximately every 5cm (centimetres)), comprises a higher modulus material, that is a material having a higher breaking load and lower elongation, than the remaining warp threads.
- [0036] In one embodiment the woven product may have a mesh size of between 0.1mm and 1.0mm. The product may be used as a tufting substrate for use in the manufacture of carpets, or the like.
- [0037] In another embodiment the woven product may have a mesh size of between 3mm and 50mm. The product may be used as an air permeable window, e.g. for use in a bag (plastic bag), or the like, e.g. intended for use in retaining perishable goods like fruit and/or vegetables.
- [0038] Alternatively the product may be used as a windbreak.
- [0039] According to a second aspect of the present invention there is provided a carpet including a tufting substrate, the substrate comprising a woven product according to the first aspect.
- [0040] According to a third aspect of the present invention there is provided a bag including an air permeable window, the window comprising a woven product according to the first aspect.
- [0041] According to a fourth aspect of the present invention there is provided a method of manufacturing a woven product comprising the steps of:
- forming a plurality of first and a plurality of second threads;
  - weaving the plurality of first and plurality of second threads together;
  - bonding adjacent contact portions provided along each first thread to respective adjacent contact portions provided along each second thread.
- [0042] Advantageously the step of bonding includes the application of heat and/or pressure to the first and/or second threads.
- 5 BRIEF DESCRIPTION OF DRAWINGS**
- [0043] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, which are:
- 10 Fig. 1 a schematic view from above of a woven product in accordance with a first embodiment of the present invention;
- 15 Fig. 2 a schematic side view of a first tape for use in the woven product of Fig. 1;
- 20 Fig. 3 a schematic end view of a portion of a woven product according to a second embodiment of the present invention;
- 25 Fig. 4 a schematic view from above of a portion of a woven product in accordance with a third embodiment of the present invention;
- 30 Fig. 5 a schematic side view of an extrusion die for use in a method of manufacture of a woven product in accordance with the present invention;
- 35 Fig. 6 a schematic perspective view of a loom for use in a method of manufacture of a woven product in accordance with the present invention;
- Fig. 7 a schematic side view of a roller apparatus for use in a method of manufacture of a woven product in accordance with the present invention;
- Fig. 8 a schematic end view of a carpet including a woven product in accordance with an embodiment of the present invention;
- Fig. 9 a schematic side view of a plastic/paper bag including a woven product in accordance with a further embodiment of the present invention.
- DETAILED DESCRIPTION OF DRAWINGS**
- 40 [0044] Referring initially to Fig. 1 there is shown a portion of a woven product, generally designated 5a, in accordance with a first embodiment of the present invention. The woven product 5a comprises a plurality of first threads 10a, and a plurality of second threads
- 45 15a, wherein contact portions 20a provided along each first thread 10a contact respective contact portions 25a provided along each second thread 15a, and wherein further each first thread 10a is bonded to each second thread 15a at the respective contact portions 20a, 25a.
- 50 [0045] Each contact portion 20a of each first thread 10a is bonded (fused) to each respective contact portion 25a of each second thread 15a by means of a thermal and/or pressure bonding process which will be described in greater detail hereinafter.
- 55 [0046] In this embodiment adjacent contact portions 20a of each first thread 10a are provided alternately on first and second opposing outer surfaces 30a, 35a of each first thread 10a. Further, adjacent contact

portions 25a of each second thread 15a are provided alternately on first and second opposing outer surfaces 40a, 45a of each second thread 15a.

[0047] Referring briefly to Fig. 2 each first thread 10a is, in this embodiment, formed from a first material having a melting point and/or softening point lower than that of a second material from which the first and second outer surface 40a, 45a of each second thread 15a are formed. It will be appreciated, therefore, that the first threads 10a may be made wholly of the first material and the second threads 15a made wholly of the second material.

[0048] In an alternative embodiment the first outer surface 30a of each first thread 10a is formed from a first material having a lower melting point than that of a second material from which the second outer surface 45a of each second thread 15a is formed, and further the first outer surface 40a of each second thread 15 is formed from a third material having a lower melting point than that of a fourth material from which the second outer surface 35a of each first thread 10a is formed. In such an embodiment the third material and the first material may be one and the same, and further the fourth material and the second material may be one and the same.

[0049] The melting point of the first/third material is between 10 and 40°C less than that of the second/fourth material, and preferably approximately 25°C less. Further, the melting point of the first/third material is approximately 120°C, while the melting point of the second/fourth material is approximately 160°C.

[0050] In this embodiment first threads comprise warp threads. However, it will be appreciated that the first threads 10a may alternatively comprise weft threads.

[0051] In this embodiment the woven product 5a is in the form of a plain weave.

[0052] Each first thread 10a comprises a core layer 50a made of one material and first and second opposing outer layers 30a, 35a made of at least one other material, the/each other material having a melting point lower than that of the one material.

[0053] In this case each second thread may be made from a further material, the further material having a higher melting point than the at least one other material(s). In this case, the further material and the one material may be one and the same.

[0054] Alternatively, each second thread 15a may comprise a further core layer 55a made from a further material and further first and second opposing layers made of at least one further other material the further material having a higher melting point than the at least one further other material. In this case the one material and the further material may be one and the same, and further the at least one other material and the at least one further material may be one and the same.

[0055] In this embodiment the one material/further material comprises polypropylene, e.g. a polypropylene homo-polymer, block co-polymer or ter-polymer. Also

the further material comprises polypropylene, e.g. a polypropylene homo-polymer, block co-polymer or ter-polymer. Further the at least one other material/one further other material comprises ethylenepropylene, e.g. an ethylenepropylene random co-polymer, ethylenepropylene block co-polymer or ter-polymer.

[0056] The first and/or second threads 10a, 15 comprise planar tapes. The first layer 30a /further first layer 40a comprises between 1% and 25% of the thickness of the tape. Further, the second layer 35a/further second layer 45a comprises between 2% and 25% of the thickness of the tape. Also each tape has an approximate thickness in the range 30µm to 300µm, and each tape has an approximate width in the range 0.5mm to 5mm.

[0057] Where the first thread 10a comprises a warp thread, the tape advantageously has a width of approximately 1mm. Advantageously also where the second thread comprises a weft thread, the tape has a width of approximately 2.5mm. Further, each tape has a breaking load of approximately 400 to 450 mN/TEX.

[0058] In this embodiment the woven product 5a may have a mesh size of between 0.1mm and 1.0mm. The product 5a may, therefore, be particularly suitable for use as a tufting substrate for use in the manufacture of carpets or the like, such as a carpet 60a as shown in Fig. 8 having tufts 65a.

[0059] Referring now to Fig. 3 there is shown a portion of a woven product, generally designated 56, in accordance with a second embodiment of the present invention, like parts of the woven product 5b being identified by the same numerals as for the woven product of Fig. 1 but suffixed with a "b".

[0060] In this embodiment the first threads 10b comprise weft tapes made of a three-layer structure similar to that of Fig. 2, while the second tapes comprise warp tapes made of a single material having a higher melting point than that of the material from which the outer layers 30b, 35b of the weft tapes are made.

[0061] Referring now to Fig. 4 there is shown a portion of a woven product, generally designated 5c, in accordance with a third embodiment of the present invention, like parts of the woven product 5c being identified by the same numerals as for the woven product of Fig. 1 but suffixed with a "c".

[0062] In this third embodiment both first and second threads 10c, 15c are three layer bi-national threads similar to that of Fig. 2.

[0063] Further, in this third embodiment the woven product 5c is in the form of a leno weave including interleaved pairs of first (warp) threads 10c. Further the mesh size of the woven product 5c, may be, for example, between 3mm and 25mm. The product 5c may, therefore, be particularly suitable for use as an air permeable article, e.g. for use as an air permeable window in a bag, such as a plastic (polythene) bag, e.g. for carrying of perishable goods such as fruit or vegetables.

[0064] Referring to Fig. 9 there is shown a bag 70c

incorporating in one side wall 75c thereof a breathable window 80c formed from the woven product 5c and retained on the wall 75c, e.g. by adhesive or plastic welding techniques.

[0065] Referring now to Figs. 5 to 7, the woven products 5a, 5b, 5c are manufactured by a method comprising the steps of:

- (a) forming a plurality of first and a plurality of second threads 10a, 10b, 10c; 15a, 15b, 15c;
- (b) weaving the plurality of first and plurality of second threads 10a, 10b, 10c; 15a, 15b, 15c together;
- (c) bonding adjacent contact portions 20a, 20b, 20c; provided along each first thread 10a, 10b, 10c to respective adjacent contact portions 25a, 25b, 25c provided along each second thread 15a, 15b, 15c.

[0066] Referring to Fig. 5 there is illustrated an extension apparatus 100 for forming the threads 10a, 10b, 10c; 15a, 15b, 15c in accordance with step (a). The apparatus 100 may be used to form mono-layer (single material) threads by feeding material into a central inlet 105 and extruding such material through a central extrusion die outlet 110. The apparatus 100 may further be used to form tri-layer (bi-component or two material) threads by feeding one material into the central inlet 105, and a second material into an outer inlet 115, and extruding the materials through the central extrusion die outlet 110 and an outer die outlet 120. In this way a three-layer bi-component tape as shown in Fig. 2 can be formed.

[0067] Once the threads 10a, 10b, 10c; 15a, 15b, 15c have been formed they may be woven in accordance with step (b) by known weaving techniques, for example, using a loom 150, as shown in Fig. 6.

[0068] Subsequent to the woven product 5a, 5b, 5c being woven, adjacent contact portions 20a, 25a of the threads 5a, 5b, 5c can be bonded together in accordance with step (c) by a process applying heat and/or pressure to the woven fabric product 5a, 5b, 5c. Fig. 7 shows a bonding process employing a 5mm wide calander 200. The calander 200 comprises a first steel dowel 205 typically heated to around 170°C rotatable about a first longitudinal axis X, and a second polyamide dowel 210 which is normally unheated. The woven product 5a, 5b, 5c is fed between the dowels 205, 210, in so doing heating and softening the product 5a, 5b, 5c and applying pressure thereto so as to activate bonding between adjacent contact portions 20a, 25a; 20b, 25b; 20c, 25c. This step has been found to promote geometric stability and regular mesh size to the product 5a, 5b, 5c.

[0069] It will be appreciated particularly by those skilled in the art that the embodiments of the present invention hereinbefore described are given by way of example only, and are not meant to limit the scope of the invention in any way.

[0070] Particularly it will be appreciated that a mono-layer warp tape and bi-component tri-layer weft may be provided, or alternatively bi-component tri-layer warp tape and mono-layer weft tape, or alternatively also bi-component tri-layer warp and weft tapes. Also, there may be provided warp threads positioned at regular intervals which have a higher modulus, that is a higher breaking load and lower elongation, than the remaining warp threads. In particular, every 50th to 60th warp thread tape (or alternatively the tape positioned at approximately every 5cm (centimetres)), comprises a higher modulus material than the remaining warp threads.

## 15 Claims

1. A woven product comprising a plurality of first threads, and a plurality of second threads, wherein contact portions provided along each first thread contact respective contact portions provided along each second thread, wherein further each first thread is bonded to each second thread at the respective contact portions.
2. The woven product according to claim 1 wherein each contact portion of each first thread is bonded (fused) to each respective contact portion of each second thread by means of a thermal and/or pressure bonding process.
3. The woven product according to claim 1 or claim 2 wherein adjacent contact portions of each first thread are provided alternately on first and second opposing outer surfaces of each first thread.
4. The woven product according to any preceding claim wherein adjacent contact portions of each second thread are provided alternately on first and second opposing outer surfaces of each second thread.
5. The woven product according to claim 4 when dependent on claim 3, wherein the first and second opposing outer surfaces of each first thread are formed from a first material having a melting point and/or softening point lower than that of a second material from which the first and second outer surfaces of each second thread are formed.
6. The woven product according to claim 4 when dependent on claim 3, wherein the first outer surface of each first thread is formed from a first material having a lower melting point and/or softening point than that of a second material from which the second outer surface of each second thread is formed, and further the first outer surface of each second thread is formed from a third material having a lower melting point and/or softening point than

- that of a fourth material from which the second outer surface of each first thread is formed.
7. The woven product according to claim 6 wherein the third material and the first material are one and the same.
  8. The woven product according to claim 6 wherein the fourth material and the second material are one and the same.
  9. The woven product according to claim 6 wherein the melting point of the first/third material is between 20 and 50°C less than that of the second/fourth material.
  10. The woven product according to claim 9 wherein the melting point of the first/third material is approximately 25°C less than that of the second material.
  11. The woven product according to claim 9 or claim 10 wherein the melting point of the first/third material is approximately 120°C.
  12. The woven product according to claim 9 wherein the melting point of the second/fourth material is approximately 160°C.
  13. The woven product according to any preceding claim wherein the first threads comprise warp threads.
  14. The woven product according to any preceding claim wherein the first threads comprise weft threads.
  15. The woven product according to any preceding claim wherein the woven product is in the form of a plain weave.
  16. The woven product according to any preceding claim wherein the woven product is in the form of a leno weave including interwoven pairs of first threads.
  17. The woven product according to any preceding claim wherein each first thread comprises a core layer made of one material, and first and second opposing outer layers made of at least one other material, the/each other material having a melting point/softening point lower than that of the one material.
  18. The woven product according to claim 17 wherein each second thread is made from a further material, the further material having a higher melting point/softening point than the at least one other material(s).
  19. The woven product according to claim 18 wherein the further material, and the one material are one and the same.
  - 5 20. The woven product according to claim 17 wherein each second thread comprises a further core layer made from a further material, and further first and second opposing layers made of at least one further other material, the further material having a higher melting point/softening point than the at least one further other material.
  - 10 21. The woven product according to claim 20 wherein the one material, and the further material are one and the same, and further the at least one other material and the at least one further other material are one and the same.
  - 15 22. The woven product according to claims 17-21 wherein the one material comprises polypropylene.
  - 20 23. The woven product according to claim 22 wherein the polypropylene is selected from a polypropylene homo-polymer or a polypropylene block co-polymer or a polypropylene ter-polymer.
  - 25 24. The woven product according to claim 18 & 20 wherein the further material comprises polypropylene.
  - 30 25. The woven product according to claim 24 wherein the polypropylene is selected from a polypropylene homo-polymer or a polypropylene block co-polymer or a polypropylene ter-polymer.
  - 35 26. The woven product according to claims 17, 18 & 21 wherein the at least one other material and/or the at least one further material comprises ethylenepropylene.
  - 40 27. The woven product according to claim 26 wherein the ethylenepropylene forms a polymer selected from ethylenepropylene random co-polymer, ethylenepropylene block co-polymer or ethylenepropylene ter-polymer.
  - 45 28. The woven product according to any preceding claim wherein the first threads comprise flat rectangular cross-section tapes.
  - 50 29. The woven product according to any preceding claim wherein the second threads comprise flat rectangular cross-section tapes.
  - 55 30. The woven product according to claim 20 when dependent upon claim 17 wherein the first layer/further first layer comprises between 1% and 50% of the thickness of the tape.

31. The woven product according to claim 26 or claim 29 wherein the second layer/further second layer comprises between 1% and 50% of the thickness of the tape.
- 5
32. The woven product according to any of claims 28 to 31 wherein each tape has an approximate thickness in the range 30 $\mu\text{m}$  (Micron) to 300  $\mu\text{m}$  (Micron).
33. The woven product according to any of claims 28 to 32 wherein each tape has an approximate width in the range 0.5mm to 5mm.
- 10
34. The woven product according to any of claims 28 to 33 wherein the first thread comprises a warp thread tape having a width of approximately 1mm.
- 15
35. The woven product according to any of claims 28 to 33 wherein the second thread comprises a weft thread tape having a width of approximately 2.5mm.
- 20
36. The woven product according to any of claims 28 to 35 wherein each tape has a breaking load of approximately 400 to 450 mN/TEX.
- 25
37. The woven product according to any preceding claim wherein first threads substantially equally spaced one from the other have a higher modulus than the remaining first threads.
- 30
38. The woven product according to claim 37 wherein the first threads having a higher modulus are spaced at approximately 5cm intervals.
39. The woven product according to any preceding claim wherein said woven product has a mesh size of between 0.1mm and 1.0mm.
- 40
40. The woven product according to any preceding claim wherein said product is used as a tufting substrate for use in the manufacture of carpets, or the like
41. The woven product according to any of claims 1 to 38 wherein said woven product has a mesh size of between 3mm and 50mm.
- 45
42. The woven product according to any of claims 1 to 38 and 41 wherein said product is used as an air permeable window for use in a bag.
- 50
43. The woven product according to claim 45 for use in a bag wherein said bag is a plastic bag.
- 55
44. The woven product according to any of claims 1 to 38 and 41 wherein said woven product is used as a windbreak.
45. A carpet including a tufting substrate, the substrate comprising a woven product comprising a plurality of first threads, and a plurality of second threads, wherein contact portions provided along each first thread contact respective contact portions provided along each second thread, wherein further each first thread is bonded to each second thread at the respective contact portions.
46. A bag including an air permeable window, the window comprising a woven product comprising a plurality of first threads, and a plurality of second threads, wherein contact portions provided along each first thread contact respective contact portions provided along each second thread, wherein further each first thread is bonded to each second thread at the respective contact portions.
47. A method of manufacturing a woven product comprising the steps of:
- (a) forming a plurality of first and a plurality of second threads;
- (b) weaving the plurality of first and plurality of second threads together;
- (c) bonding adjacent contact portions provided along each first thread to respective adjacent contact portions provided along each second thread.
48. The method according to claim 47 wherein the step of bonding includes the application of heat to the first threads.
49. The method according to claim 47 wherein the step of bonding includes the application of heat to the second threads.
50. The method according to claim 47 wherein the step of bonding includes the application of heat to the first and second threads.
51. The method according to claims 47 to 50 wherein the step of bonding further includes the application of pressure to said threads.

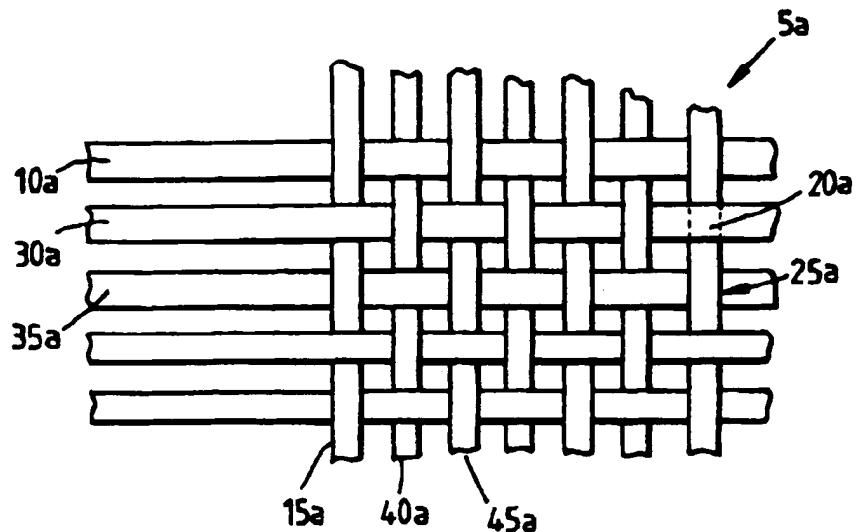


Fig. 1

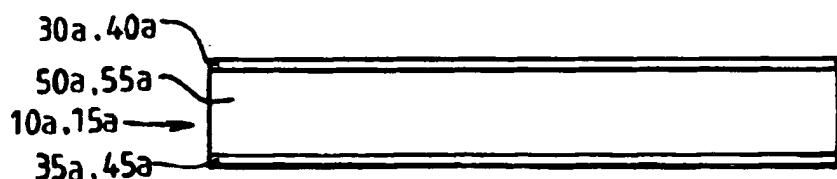


Fig. 2

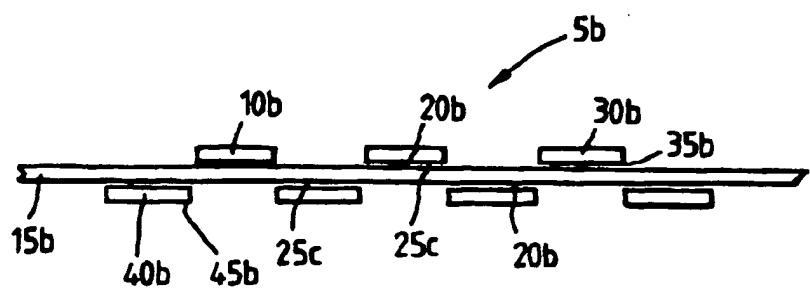


Fig. 3

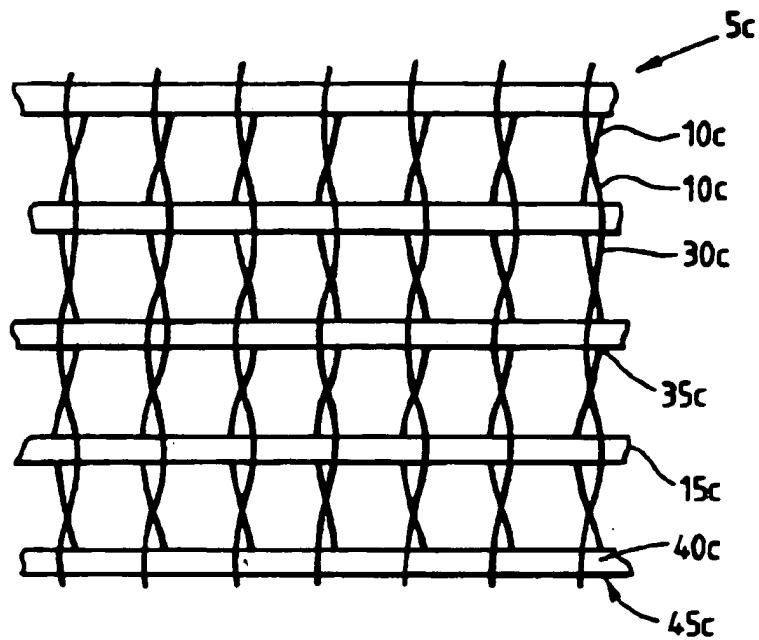


Fig. 4

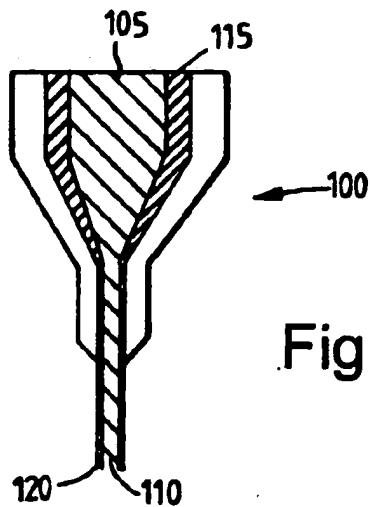


Fig. 5

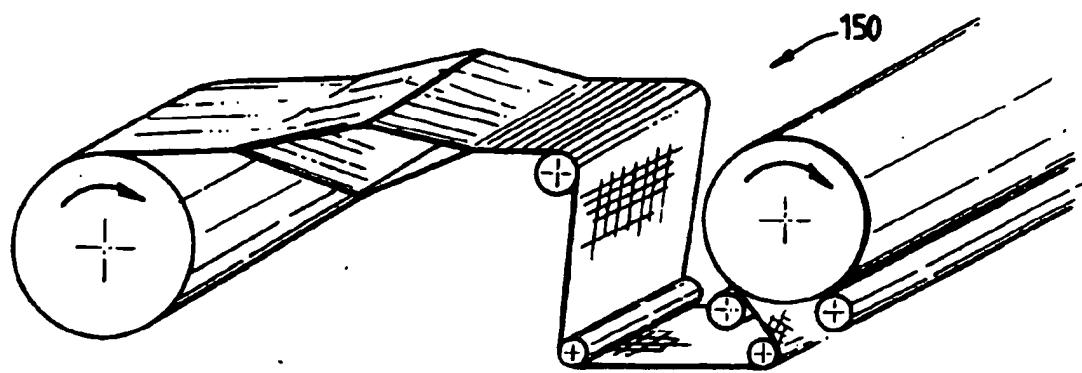


Fig. 6

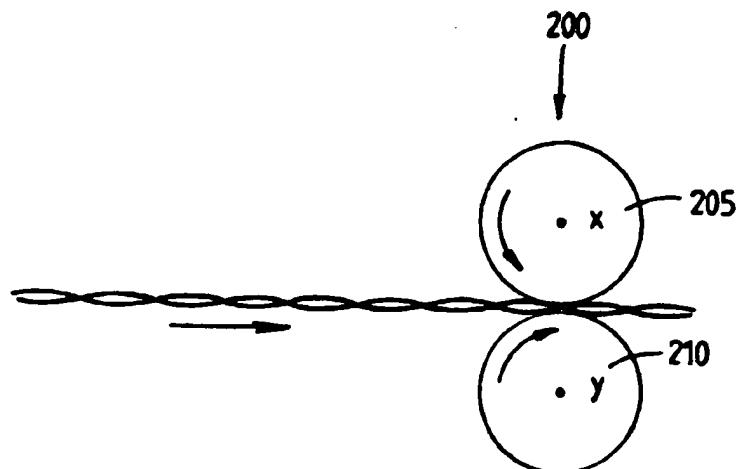


Fig. 7



Fig. 8

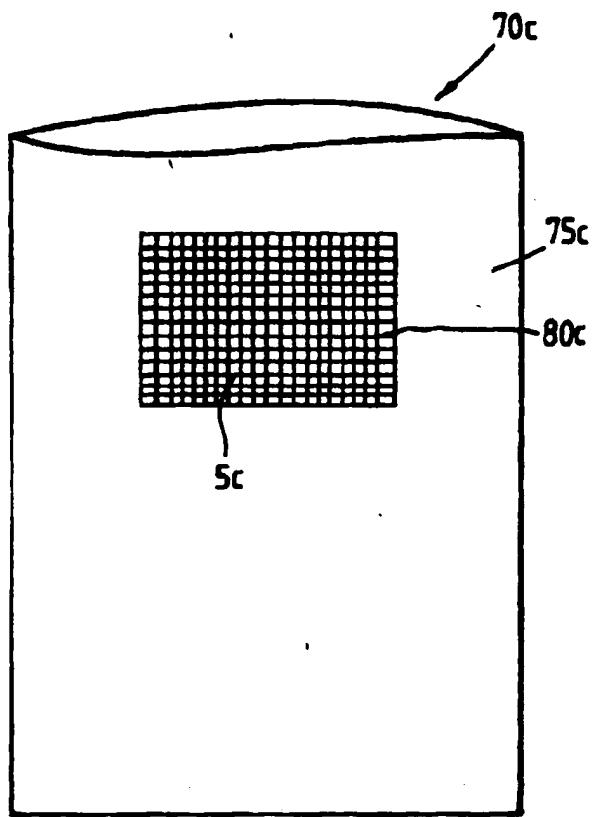


Fig. 9